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Measurements and Measuring Instruments / Devices

سُورَةُ الفَاتِحَة

بِسْمِ ٱللَّهِ ٱلرَّحْمَٰنِ ٱلرَّحِيمِ

ٱلْحَمْدُ لِلَّهِ رَبِّ ٱلْعَٰلَمِينَ

ٱلرَّحْمَٰنِ ٱلرَّحِيمِ مَٰلِكِ يَوْمِ ٱلدِّينِ

إِيَّاكَ نَعْبُدُ وَإِيَّاكَ نَسْتَعِينُ ٱهْدِنَا

ٱلصِّرَٰطَ ٱلْمُسْتَقِيمَ صِرَٰطَ ٱلَّذِينَ أَنْعَمْتَ

عَلَيْهِمْ غَيْرِ ٱلْمَغْضُوبِ عَلَيْهِمْ

وَلَا ٱلضَّآلِّينَ

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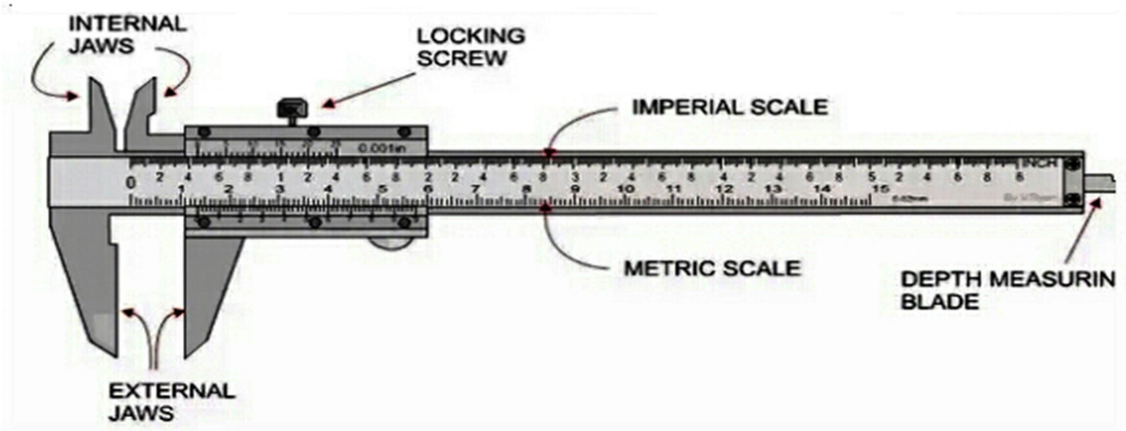

Linear measurements

Linear measurement is the measurement of Diameters, Lengths, Thickness, Height; and also which includes internal measurements and external measurements.

The Linear measurements are classified into two types, they are.
1. Precision Instruments
2. Non – Precision instrument

Linear measurements of Precision Instruments

Following are the precision instruments which possess high degree of accuracy in measuring the dimensions

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Vernier Calipers
Slip Gauges
Micrometers
Vernier Height gauge and Depth Gauge
Vernier Micrometer
Depth micrometer
Inside Micrometer and Outside micrometers
Telescopic Gauge
Differential screw micrometers
screw thread micrometers
Sheet metal micrometer
Spline micrometer
Tube micrometer
Disc Type Micrometer
V- anvil micrometer

Linear measurements of Non – Precision instrument

The Non precision measuring instruments are.

Calipers
Transfer Calipers
Outside and Inside Calipers
Spring Calipers
Odd leg Calipers
Steel Rule

The Calipers are comprised of the following;

Angle gauges
Clinometers
Sine bars
Sine Center
Sine Table
Spirit Level
Plain index center
Optical instruments

Protractors
The Protractors are divided into may three times.
Dial Bevel Protractor.
Optical bevel Protractors
Vernier Bevel Protractors.

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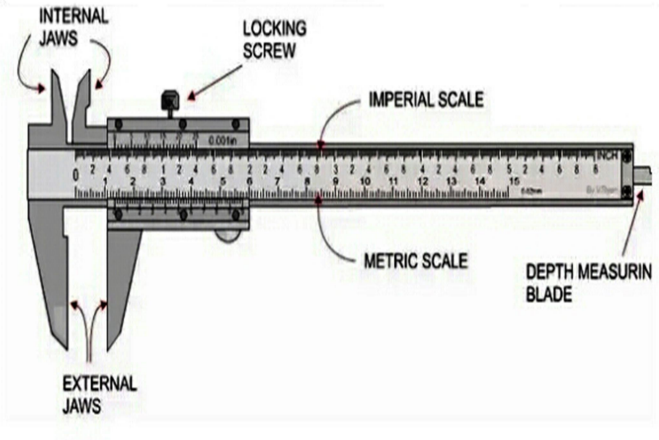
$$\text{Least count} = \frac{\text{Value of one main scale division}}{\text{Total number of division on vernier scale}}$$

$$\text{let's assume} \quad = \frac{1}{10} = 0.1 \text{ mm is least count}$$



Vernier Caliper

The veneer caliper is an extremely precise measuring instrument; it is used to measure internal and external distances extremely accurately – the error may be as little as 0.05 mm – depending on the make. The VERNIER is a small movable graduated scale for obtaining fractional parts of subdivisions on a fixed main scale of any measuring instrument. With a normal scale we may be able to measure down to 0.50 mm or so, while with a vernier scale the least count may be 0.10 mm. Usually vernier calipers have both imperial (inches) and metric (mm) scales.

A vernier caliper is a precision measuring tool. It can be used for three types of measurements, outside distance (such as the length of an object) , inside distance such as the width of a groove or the diameter of a large hole, and depth, such as the depth of a hole or the height of a step.

Vernier calipers come in many sizes. A common type measures 0 to 6 inches.

Modern calipers are digital – in the sense it has an LCD display on which the reading appears – there is no possibility of human error in reading the scale.

The smallest vernier caliper that can be bought off-the-shelf is 150 mm – meaning the jaws open to a maximum of 150 mm. The largest ones go up to 2000 mm.

Vernier Caliper's Least Count:

The difference between the value of one main scale division and the value of one Vernier scale division is known as least count of the Vernier.

Least count of vernier caliper is the smallest value that we can measure from this device. To calculate the least count of vernier caliper is the value of one main scale division divided by the total number of division on the vernier scale.

Let's assume if the value of one main scale division is 1mm and the total number of division on vernier scale 10mm then the least count will be 0.1mm. Thus least count is defined as the smallest distance that can be measured from an instrument.

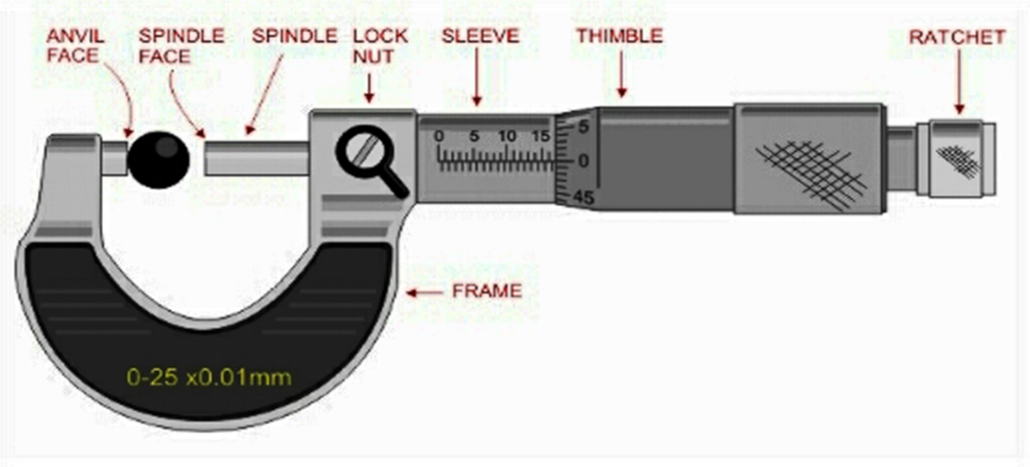
Micrometer

Introduction to micrometer

The micrometer is an improvement over the measurement of the vernier calliper scale

The accuracy of vernier calliper remains to be 0.02 mm, but most of the engineering precision work demands greater accuracy with sensitivity for which an instrument having both these should be used. The most familiar

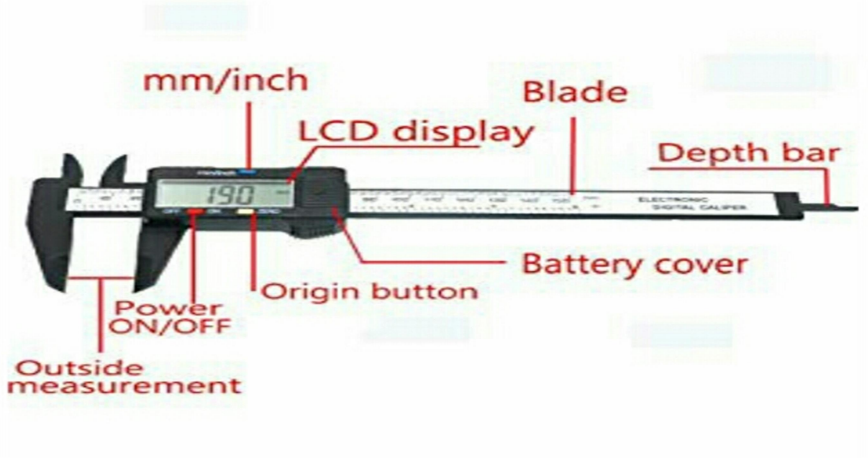
precision measuring instrument in the workshop is micrometer.



Micrometer works on the principle of screw and nut. The longitudinal movement of the spindle during one rotation is equal to the pitch of the screw i.e., the distance moved by the nut along the screw is proportional to the number of revolutions made by the nut. Therefore by controlling the number of revolution and fractions of a revolution made by the nut, the distance it moves along the screw can be accurately predicted
A micrometer is a precision measuring instrument, used to obtain very fine measurements and available in metric and imperial versions.
Metric micrometers typically measure in 0.01mm increments and imperial versions in 0.001 inches.

The measurements they provide can be more accurate than those given by other measuring devices such as dial calipers or vernier calipers, but depend very much on the user's care. They are widely used in mechanical engineering for precisely measuring components.
Most micrometers have two scales: a primary scale, on the barrel or sleeve, and a secondary scale, on the thimble. Values are taken from each of these scales and combined to make the total measurement.
Micrometers have two scales: a primary scale, on the barrel or sleeve, and a secondary scale, on the thimble. Values are taken from each of these scales and combined to make the total measurement. A micrometer uses a calibrated screw (found on the spindle) for measurement. Every time the spindle makes a complete revolution, the space between the measuring faces of the instrument (the spindle and the anvil) is adjusted by 0.025 inch or 0.5mm. This is the smallest value that can be represented on the primary sleeve scale.

A micrometer uses a calibrated screw or thread (found internally on the spindle) for measurement.
Every time the spindle makes a complete revolution, the space between the measuring faces of the instrument (the spindle and the anvil) is adjusted by 0.5mm for metric versions and by 0.025 inch for imperial micrometers. These are the smallest values that can be represented on the primary sleeve scale.



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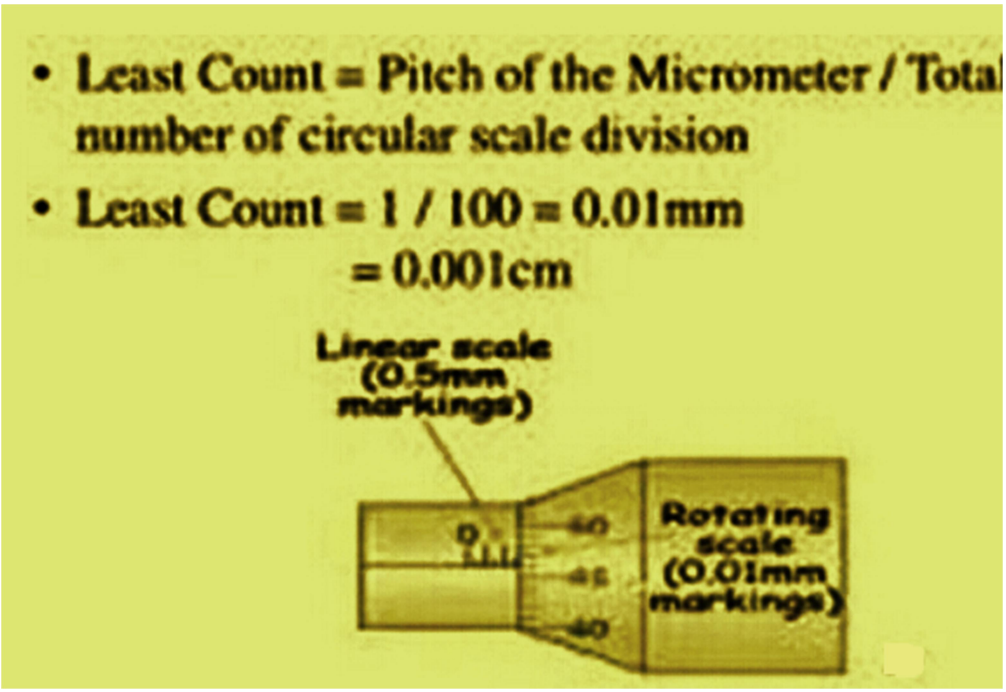
Although micrometers are more accurate than other types of caliper, they have a more limited range. Micrometers typically have a measuring range of 1 inch (25mm). For instance, 0-1 inches (0-25mm), 1-2 inches (25-50mm) etc

Although micrometers are highly accurate measuring devices, they are limited in their range.

Micrometers typically have a measuring range of 25mm and 1 inch. For instance, metric versions measure 0-25mm, 25-50mm, 50-75mm etc, and imperial versions measure 0-1 inches, 1-2 inches, 2-3 inches etc.

There a number of different types of micrometer. The most common types are outside micrometers, inside micrometers and depth micrometers.

Least count of Micrometer


• Least Count = Pitch of the Micrometer / Total number of circular scale division
• Least Count = 1 / 100 = 0.01mm
= 0.001cm
Linear scale (0.5mm markings)
Rotating scale (0.01mm markings)

Least count = pitch ÷ Total no of division on the circular scale

Pitch - distance moved by the screw in one complete rotation and it's magnitude is distance between two corresponding consecutive thread of the screw.
In micrometer pitch=distance moved by screw ÷ No of complete rotation given to screw
Pitch=4mm÷4mm=1mm
Least count =1mm÷100=0.01mm

Inside Micrometer

An inside micrometer is a device designed to precisely measure things such as the inner diameter of holes. Where a standard micrometer might be used to measure the outer diameter of a bolt, an inside micrometer could be used to measure the inner diameter of a nut. There are several designs for the inside micrometer, though they all perform this same basic function. All micrometers are designed to make very precise measurements, but the micrometers themselves can be either small or quite large. Each inside micrometer will have both a minimum and maximum diameter it is able to measure, so it's common to find inside micrometer sets.

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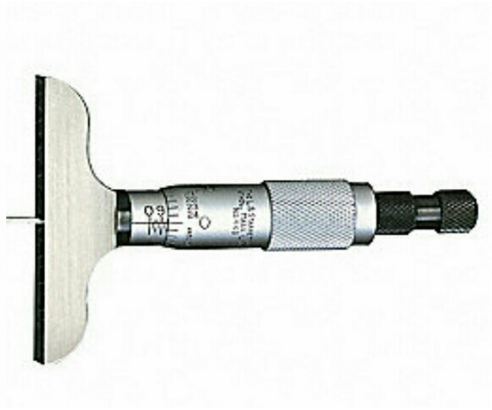
There are several inside micrometer designs, though the most common are tubular- and caliper-type micrometers. A tubular inside micrometer consists of a cylindrical tube that may be placed in the inner diameter of a hole or ring to precisely determine the diameter, or between two parallel surfaces to measure the distance between them. Once the tubular micrometer is in place, there will usually be a way to extend the tube until it contacts both sides of the inner diameter of whatever is being measured. Caliper-type micrometers generally feature one stationary and one movable caliper mounted on a tube, with the ability to adjust the movable caliper out along the length of the tube to make a measurement.

Both standard and digital inside micrometers are available, with both relying on a screwing mechanism to display very accurate readings. Standard micrometers can be read by examining markings on the barrel and thimble of the micrometer, because very small distances are represented by greatly magnified rotational distances as the thimble is turned. Digital micrometers operate in the same way as standard micrometers, but they will have a digital readout on the barrel that negates the need to examine the barrel and thimble for scale and distance markings. The unique feature of inside micrometers is their ability not only to measure small diameters and other distances very accurately, but also to measure very large diameters and distances accurately. To this end, inside micrometers may be found in many sizes. There are also sets that include a single measurement head and a number of tubes in varying lengths that can be attached to the head. This type of set can be used to measure a wide variety of inside diameters and various parallel surfaces without the need for multiple micrometers.

Depth Micrometer

A depth micrometer is a sensitive tool that is used to measure the depth of small holes and bores. Used by engineers and mechanics, this device has a series of unique pieces that help it dial in an exact measurement. Reading depth micrometers is a precise science that must be performed carefully. For those without the time or patience, technology has provided micrometer enthusiasts with a digital option for even better readings. Knowing the precise measurement of a bore opening is important business for engineers and mechanics.



It can mean the difference between a perfectly functioning engine and a disaster. The key to properly using the depth micrometer is patience, because the readings are highly sensitive, and hurrying through a measurement will not provide accurate results. A depth micrometer is comprised of five key parts that make this stubby, screwdriver-looking device. The spindle is the most important part of the depth micrometer calibration process because it is the thin probe at the end of the device that performs the actual measuring. Further up that rod, the base of the measuring device is the spacer and spindle lock screw that are used for tightening and loosening. The actual measurements are taken on the thickest part of the micrometer, the rounded handle-like parts called the sleeve and thimble.

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These parts are marked with numbers representing measurements that can be adjusted to get precise readings of a bore. In order to get that precise reading, the micrometer's spindle must be gently inserted into an opening that needs to be read. Slowly turning the sleeve will descend the spindle further into the hole. Turning this dial until the spindle touches the end of the opening will result in an accurate measurement. This measurement can be read by removing the micrometer from the opening and looking at where the numbers are lined up along the sleeve and thimble. With anything measured by hand, there always are risks of user error, and it is possible to not get a perfect reading with a traditional depth micrometer. Measurement has become more accurate with the invention of the digital depth micrometer. This machine resembles the previous hand-controlled models, except that it has a small digital screen near the end. By simply inserting the spindle into a bore, the exact depth measurement appears on the screen for a more accurate reading.

Screw Thread Micrometer

The screw thread micrometer is an instrument used for measuring pitch diameter of screw threads to an accuracy of 0.01 mm and 0.001 in. It consists of the same parts as that of outside micrometer with the only difference that the movable spindle is pointed and the end of the anvil is of the same form as the screw thread to be measured. In measuring screw threads, the angle of the spindle point and sides of the anvil vee contact the surfaces of the thread so that the reading of the instrument indicates the pitch diameter of the thread. The graduations on the sleeve and the thimble are similar to that of an external micrometer.

Dial Indicators

An indicator is any of various instruments used to accurately measure small distances and angles, and amplify them to make them more obvious. The name comes from the concept of indicating to the user that which their naked eye cannot discern; such as the presence, or exact quantity, of some small distance (for example, a small height difference between two flat surfaces, a slight lack of concentricity between two cylinders, or other small physical deviations).

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Many indicators have a dial display, in which a needle points to graduations in a circular array around the dial. Such indicators, of which there are several types, are often called dial indicators. Other types of indicator include mechanical devices with cantilevered pointers and electronic devices with digital displays. Indicators may be used to check the variation in tolerance during the inspection process of a machined part, measure the deflection of a beam or ring under laboratory conditions, as well as many other situations where a small measurement needs to be registered or indicated.

Vernier Height Gauge

A vernier height gauge is typically used to take precise vertical measurements of various objects. It is possible to measure many different things with the gauge, but they are most often used in metalworking and other related industries. They often have a scribing tool as the measurement level, allowing the operator to repeatedly mark vertical distances on pieces of metal that can then be worked on. Heights or vertical distances may also be measured using the bottom of the scribe.

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The name of this tool is derived from the special, sliding vernier scale that the devices make use of. Vernier scales are an additional measurement tool that can augment a straight scale and allow for more accurate measurement. This is typically achieved by a fixed scale printed along the length of the measuring device, while a sliding vernier scale is on the moving component. When the zero mark on the sliding scale is located between two graduations on the fixed scale, the operator can find the location where the vernier and fixed graduations line up to determine a precise measurement. This system can allow for a much higher measurement resolution than is normally possible with a straight scale. When used in metalworking and other related industries, a vernier height gauge is typically equipped with a scribing tool. This will often take the form of adjustable level so that it can be set to particular heights and then used to scribe marks on a piece of metal. Operators may use this functionality to mark many pieces of metal with identical and precise measurements. The bottom side of the scribing tool can also be used to measure vertical distances, rather than inscribing height markings.

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In order to ensure the continued accuracy of a gauge, it is typically possible to adjust the level. This may be necessary if the scribing tool becomes worn or damaged, and is often adjusted through the use of a feed screw. It may be possible to make fine adjustments using the feed screw if the height gauge is out of calibration. Vernier height gauges are one of the two main types of tools used to make accurate vertical measurements. The other type is typically referred to as an electronic height gauge. Rather than a vernier scale, these gauges have a digital readout. Digital height gauges may be more expensive than their vernier counterparts, but typically take less training or expertise to read correctly.

Slip Gauges

Gauge blocks (also known as gage blocks, Johansson gauges, slip gauges, or Jo blocks) are a system for producing precision lengths. The individual gauge block is a metal or ceramic block that has been precision ground and lapped to a specific thickness. Gauge blocks come in sets of blocks with a range of standard lengths. In use, the blocks are stacked to make up a desired length.

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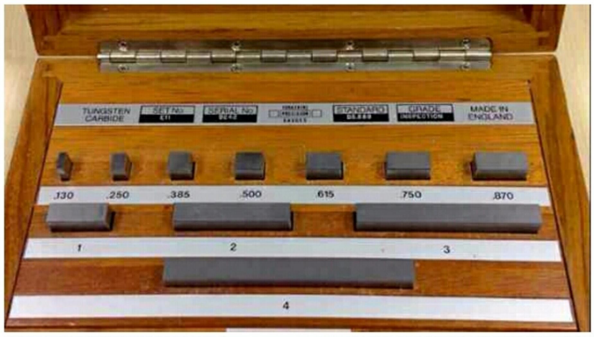
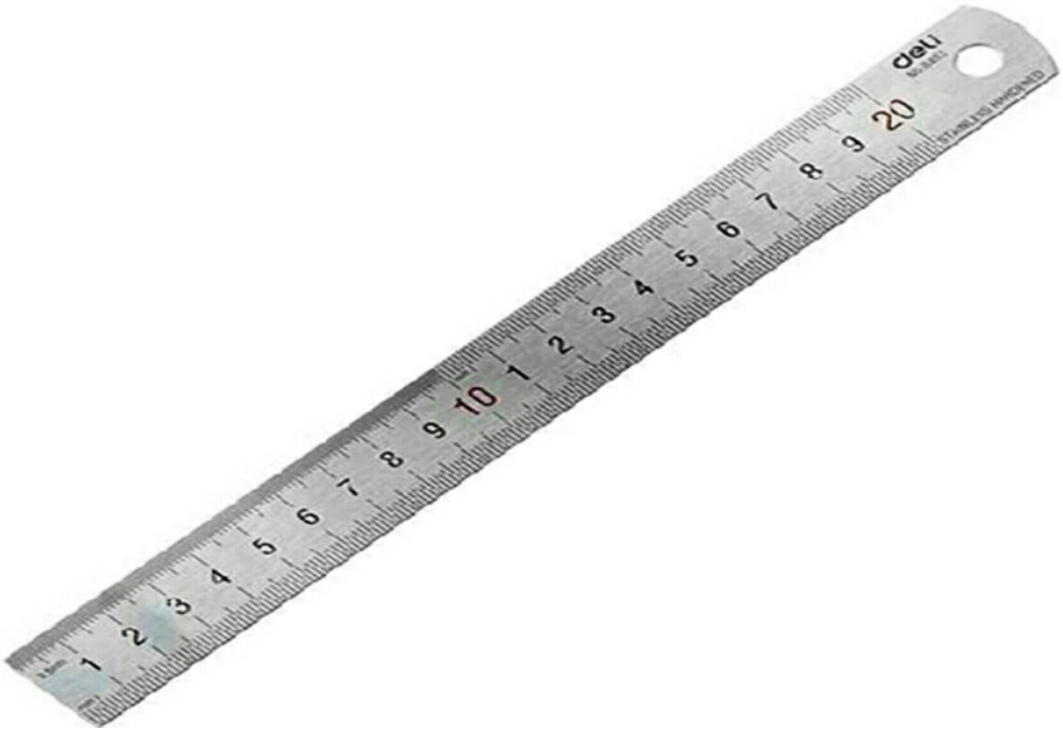
Slip Gauges

An important feature of gauge blocks is that they can be joined together with very little dimensional uncertainty. The blocks are joined by a sliding process called wringing, which causes their ultra-flat surfaces to cling together. A small number of gauge blocks can be used to create accurate lengths within a wide range. By using 3 blocks from a set of 30 blocks, one may create any of the 1000 lengths from 3.000 to 3.999 mm in 0.001 mm steps (or .3000 to .3999 inches in 0.0001 inch steps). Gauge blocks were invented in 1896 by Swedish machinist Carl Edvard Johansson They are used as a reference for the calibration of measuring equipment used in machine shops, such as micrometers, sine bars, calipers, and dial indicators (when used in an inspection role). Gauge blocks are the main means of length standardization used by industry.



Steel Rule

It is also known as scale. It is a line measuring device. It is the simplest and most common measuring instrument used in inspection. It works on the basic measuring technique of comparing an unknown length to the one previously calibrated. It consists of a strip of hardened steel having line graduations etched or engraved at interval of fraction of a standard unit of length.

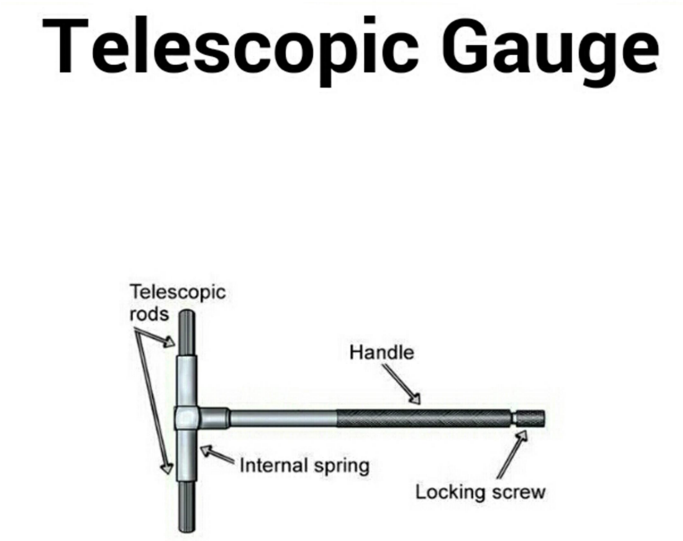


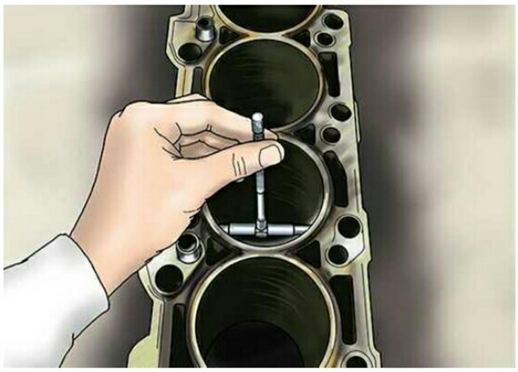
Depending upon the interval at which the graduations are made, the scale can be manufactured in different sizes and styles. Various possible combinations of scales are found depending upon whether the scale is graduated either on both sides and both edges or on edges of only one side. The scale can be either 150 mm long or 300 mm or 600 mm or 1000 mm long. The scale need not be graduated uniformly throughout its length. In some part e.g. it may have 10 divisions of centimetre, in some portion 20 divisions, so that it can be

used for all types of work and the particular range chosen depending upon the accuracy required.
Certain scales have got some attachments and special features with them to make their use more versatile e.g., very small scales may be provided with a handle to use it easily. They may be made in folded form so that these can be kept in pocket also. Certain scales take into account the shrinkage of materials after cooling and are called shrink rules. These are used in foundry and pattern making shops. Scales can also be attached with an adjustable shoulder to make them suitable for depth measurement

Bevel GaugeA sliding T bevel, also known as a bevel gauge or false square is an adjustable gauge for setting and transferring angles. The handle is usually made of wood or plastic and is connected to a metal blade with a thumbscrew or wing nut. The blade pivots and can be locked at any angle by loosening or tightening the thumbscrew. The bevel can be used to duplicate an existing angle, or set to a desired angle by using it with any number of other measuring tools (such as a protractor, or framing square)

Telescopic Gauge



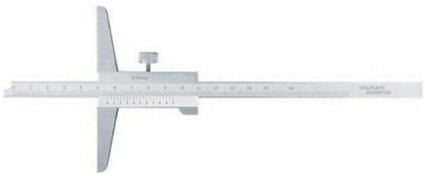


A telescopic gauge is a measuring tool with spring-loaded plunges used together with a micrometer to measure the inside of holes or bores. Telescoping gauges are made insets to measure from small to very large bores. The telescoping gauge has a handle that is attached to two spring-loaded plungers. Using the handle , place the telescoping gauge into the bore . Release the lock screw on the handle. The spring-loaded plungers will come out and touch the side of the bore. Rock the gauge back and forth to be sure it is square in the bore. Turn the lock screw to lock the plungers in position. Remove the telescoping gauge from the bore.

The exact size of the hole is found by measuring across the two ends of the plungers with an outside micrometer. Inside calipers can be used to measure any gap that their legs will fit into, and because those legs are not hardened (and also because the tool is so inexpensive), they can be ground thinner to fit into really narrow cracks. Still, they are likely used most of the time to measure the inside diameter (I. d.) of holes. Another tool that can be used for exactly the same purpose is the telescoping gauge. Although its working ends are larger than those

of an inside measurements as the I. d. of a snap ring groove, the telescoping gauge is definitely preferable for gauging simple round holes because of its potentially greater level of accuracy. That advantage comes from the construction of the tool: It amounts to two straight legs, one of which telescopes into the other, working against a spring that tends to extend it. Part of the improvement in accuracy over calipers is provided by that spring, which automatically controls the gauging force. Another aid to accuracy is a handle attached exactly at right angles to the fixed leg.

Depth Gauge



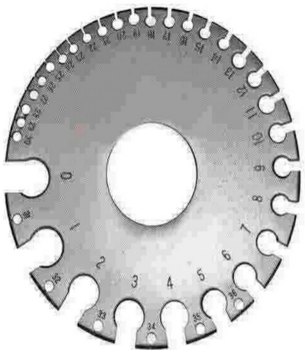
Digital depth gauge

The depth gauge micrometer is a precision measuring instrument, used by engineers to measure depths. Each revolution of the rachet moves the spindle face 0.5mm towards the bottom of the blind hole. The diagram below shows how the depth gauge is used. The ratchet is turned clockwise until the spindle face touches the bottom of the blind hole. The scales are read in exactly the same way as the scales of a normal micrometer

Wire Gauge

Wire Gauge

Wire gauge is used for the measurement of wire diameter. This determines the amount of electric current a wire can safely carry, as well as its electrical resistance and weight.



Dividers

Divider, instrument for measuring, transferring, or marking off distances, consisting of two straight adjustable legs hinged together and ending in sharp points. It is used principally in drafting for the accurate transfer of dimensions from a measuring scale and in machine shops for scribing lines on surfaces, usually machined, with dimensions taken from a ruler. A compass is essentially a divider in which one of the points has been replaced by a pencil or other marking device. The compass is useful for scribing circles or arcs of circles; it usually includes a scale to indicate the radius of the circle being scribed.

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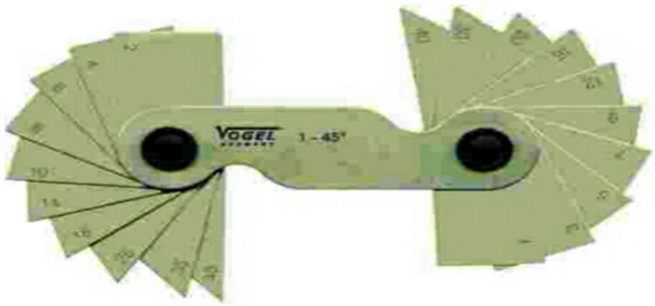
Divider

Angle Gauges



Angle gauges are used for measuring and setting out angles in the workshops where precision work in the measurement of angles are required. These are wedge shaped steel blocks and their working faces are finished in the same manner as slip gauges, enabling them to be wring together in combinations.

A full set comprises twelve pieces divided into three series: degrees, minutes and fractions of a minute as follows: 1,3,9,27 and 41 degress; 1,3,9 and 27 minutes; 0.1,0.3 and 0.5 minute with twelve separate gauges used in conjunction with a precision square, it is possible to set up any angle between 0 and 3600 to be built up in steps of 6 seconds by wringing blocks together in additive or subtractive manner. Thus, taking the 10, 30, 90 blocks. 30+10 =40, 90-(3+1)0 = 50, 90-10= 80 and so on. There are two sets of gauges available, designated as A and B. The standard B contains all the 12 gauges, while standard A contains one additional gauge of 0.05’ (3’ ’) which enables combinations to be built up to 3’ ’ . The block formed by a combination of a number of these gauges is rather bulky and cannot always be conveniently used directly to the work, with angle measuring device such as a bevel autocollimator.

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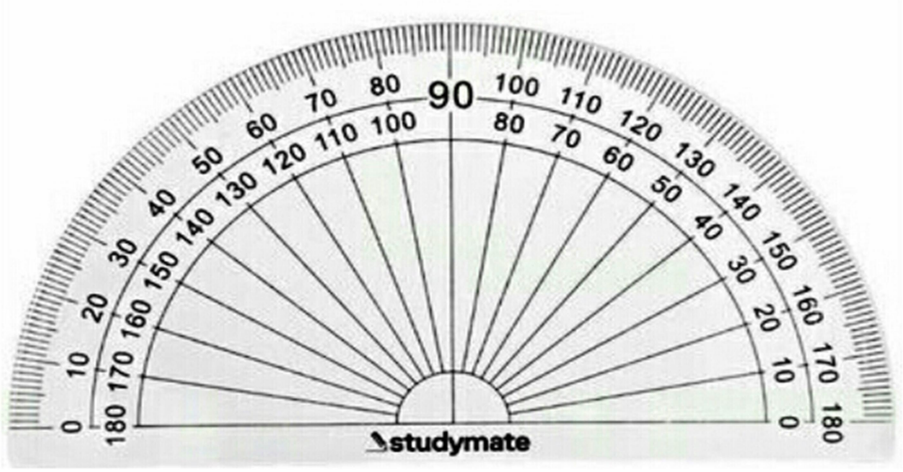
Protractor



A protractor is a measuring instrument, typically made of transparent plastic or glass, for measuring angles. Most protractors measure angles in degrees (°). Radian-scale protractors measure angles in radians. Most protractors are divided into 180 equal parts. They are used for a variety of mechanical and engineering-related applications, but perhaps the most common use is in geometry lessons in schools. Some protractors are simple half-discs. More advanced protractors, such as the bevel protractor, have one or two swinging arms, which can be used to help measure the angle.

Bevel Protractor

The bevel protractor is used to establish and test angles to very close tolerances. It reads to 5 minutes or 1/20o and can be used completely through 360o.

The bevel protractor consists of a beam, graduated dial and blade which is connected to swivel plate (with Vernier scale) by thumb nut and clamp. When the edges of the beam and blade are parallel, a small line on the swivel plate coincides with the zero line on the graduated dial, and when any measurement of an angle between the beam and the blade of 90 degrees or under is desired, the reading may be obtained direct from the position of the line on the swivel plate with regard to the graduation numbers on the dial. But remember this: To obtain the measurement of the angle between the beam and the blade of over 90 degrees subtract the number of degrees as indicated on the dial from 180 degrees. This is because, the dial is graduated from opposite zero marks to 90 degrees each way.

Since the spaces, both on the main scale and the vernier scale, are numbered both to the right and to the left from zero, any angle can be measured. The readings can be taken either to the right or to the left, according to the direction in which the zero on the main scale is moved. Reading the bevel protractor vernier scale: The bevel protractor vernier scale indicates every five minutes or 1/20 of a degree. Each space on the vernier scale is 5 minutes less than two spaces on the main scale. Twenty four spaces on the vernier scale equal in extreme length twenty three double degrees. Thus, the difference between the space occupied by two degrees on a main scale and the space of the vernier scale is equal to one twenty fourth of two degrees or one twelfth of one degree (or five minutes). Read off directly from the main scale the number of whole degrees between 0 on this scale and the 0 of the vernier scale. Then count, in the same direction, the number of spaces from the zero on the vernier scale to a line that coincides with a line on the main scale; multiply this number by 5 and the product will be the number of minutes to be added to the whole number of degrees.

Sine Bar

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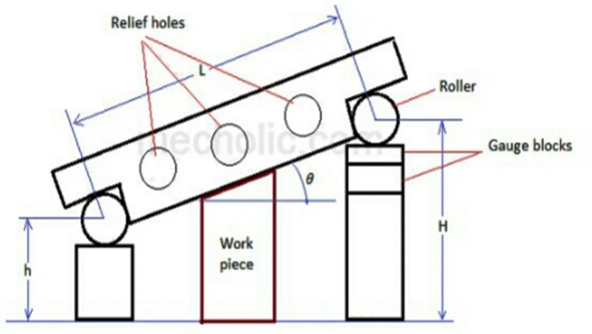
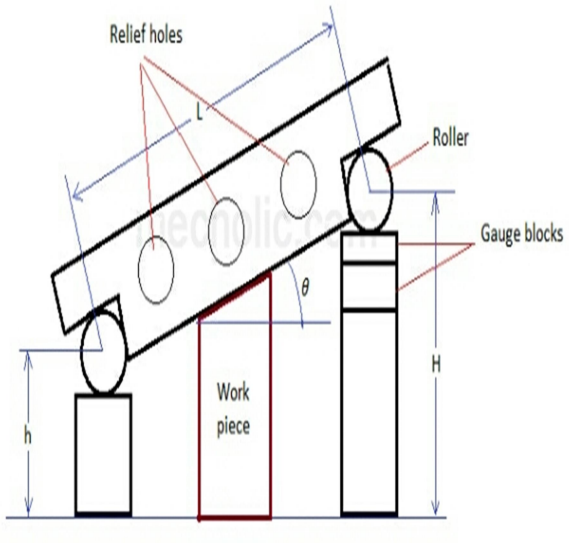
Sine Bar





A sine bar consists of a hardened, precision ground body with two precision ground cylinders fixed at the ends. The distance between the centres of the cylinders is precisely controlled, and the top of the bar is parallel to a line through the centres of the two rollers. The dimension between the two rollers is chosen to be a whole number (for ease of later calculations) and forms the hypotenuse of a triangle when in use. When a sine bar is placed on a level surface the top edge will be parallel to that surface. If one roller is raised by a known distance, usually using gauge blocks, then the top edge of the bar will be tilted by the same amount forming an angle that may be calculated by the application of the sine rule.

Try Square

The try square has a blade (straight edge) and a stock (beam) which is fixed together at exactly 90 degrees. The stock is much thicker than the blade. The edge of the blade and the stock are perfectly sharp and straight. The try square may be made entirely of steel or wood or it may have a stock of wood and a blade of steel. The blades have metric or imperial graduations or a combination of both.
The try square is used mostly for:

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1) Laying out lines perpendicular to an edge or side of a board.

2) Checking edges and ends of boards to see if they are square with adjoining surfaces.

3) Checking the width or thickness of narrow boards.

4) Measuring short distances.

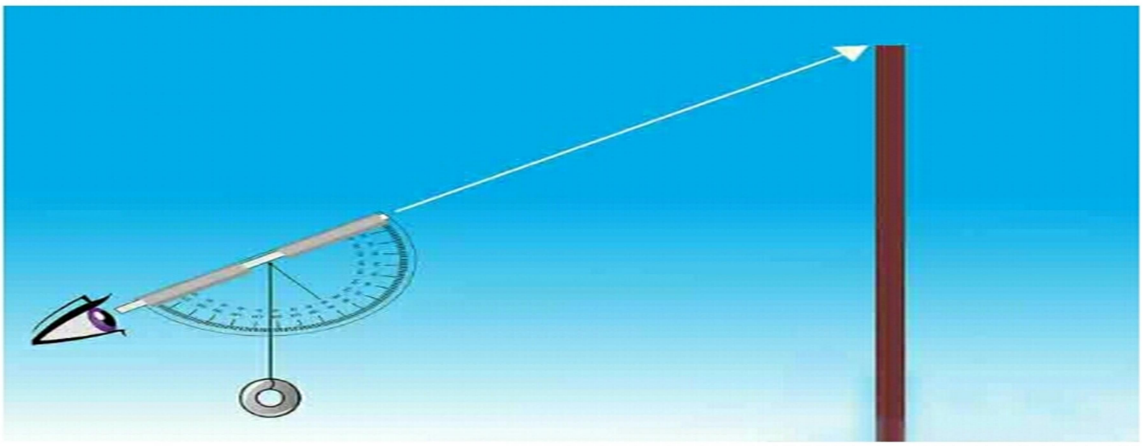
5) Checking flatness.

Clinometers

A clinometer or inclinometer is an instrument for measuring angles of slope (or tilt), elevation or depression of an object with respect to gravity. It is also known as a tilt meter, tilt indicator, slope alert, slope gauge, gradient meter, gradiometer, level gauge, level meter, declinometer, and pitch and roll indicator.

Clinometers measure both inclines (positive slopes, as seen by an observer looking upwards) and declines (negative slopes, as seen by an observer looking downward) using three different units of measure: degrees, percent, and topo.

Clinometers



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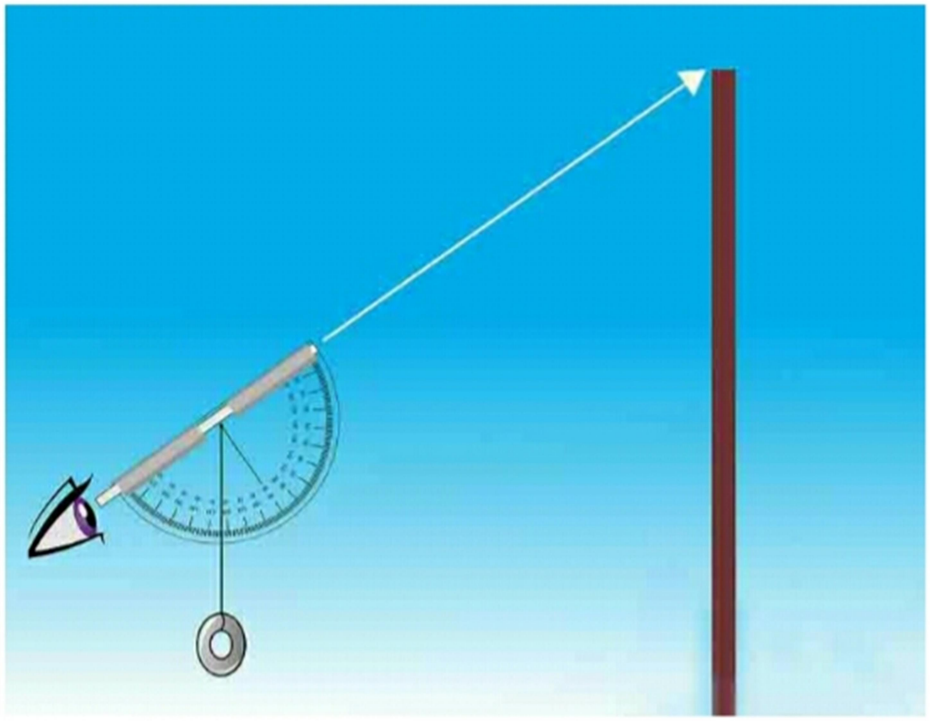

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